Report No. 7-RD-65

STANDARDIZATION TASK REPORT
TASK NO. 2

ESTABLISHMENT OF STANDARDIZATION DATA FOR MONEL AND K-MONEL FASTENERS

Conducted for:
Department of the Navy
Bureau of Ships

Contract No. NObs-90493

26 April 1965

VALUE
ENGINEERING COMPANY
2316 Jefferson Davis Highway - Alexandria, Va. - 548-8300

eport No. 7-RD-65

STANDARDIZATION TASK REPORT
TASK NO. 2

ESTABLISHMENT OF STANDARDIZATION DATA FOR MONEL AND K-MONEL FASTENERS

Conducted for:
Department of the Navy
Bureau of Ships

Contract No. NObs-90493

26 April 1965

Conducted by: E. Goodman
T. Hogland
J. Miller

Approved by: H. P. Weinberg
H. P. Weinberg, Director
Research and Development

VALUE ENGINEERING COMPANY
2316 Jefferson Davis Highway
Alexandria, Virginia

I PURPOSE

The purpose of testing performed in this task is (1) to determine thread distortion caused by various amounts of thread interference, (2) to evaluate changes in material as a result of thread interference, length of engagement, and axial stud loading to its breaking point, and (3) to produce comparative data on break-away torque and prevailing back-out torque of the stud, and corresponding torques for backing off self locking nuts.

The following thread forms and fits are to be investigated.

	Stud Thread Class	Engaged in Tapped Hole Thread Class
1.	5 cut	5
2.	5 rolled	5
3.	3A cut	3B
4.	3A rolled	3B
5.	2A cut	3B
6.	2A rolled	3B
7.	5 cut	3B
8.	5 rolled	3B
9.	5 cut 1/	3B

1/ Using sealant in accordance with MIL-S-22473.

Each of these nine fits must be tested using K-monel studs engaged in Monel casting, HTS plate, HY80 plate, and HY80 casting and Monel studs engaged in HTS and HY80 plates.

II MATERIALS TESTED

A. Requirements:-

1. K-Monel Studs - K-monel studs used in the performance of this task must conform to Military Standard MS18116 and the applicable requirements of specifications QQ-N-286 and MIL-B-857.

2. Monel Studs - Monel studs used in the performance of this task must conform to the applicable requirements of QQ-N-281 and MIL-B-857, except that the studs must have the following mechanical properties:

Tensile strength - 80,000 psi, minimum

Yield strength - 40,000 psi, minimum (0.2 percent offset)

Elongation in 2 inches - 20 percent, minimum

3. Plate Materials - Plate materials must conform to the following specifications.

Material	Specification
High Tensile Steel Plate (HTS)	MIL-S-16113 Grade HT
HY80 Steel Plate	MIL-S-16216
Cast HY80 Steel	MIL-S-23008
Cast Monel	QQ-N-288

4. Porosity - All cast materials must be subjected to radiographic examination to ascertain freedom from porosity.

5. Nuts - The nuts used in performing this task must conform to Military Standard MS17828, Nuts, Self Locking (Nylon Insert), Hexagon, Regular Height, 250°F., Nickel-Copper Alloy.

B. Actual Chemical and Mechanical Properties:-

Tables I and II are a compilation of the required and actual chemical composition and mechanical properties, respectively, of the studs and materials used for tests performed in this task.

All cast materials were subjected to radiographic examination. The cast HY80 was found to be free from from porosity. Several plates of cast

monel had an area of porosity which was marked so that no holes were drilled and tapped in these areas.

Table I Chemical Composition

Material	Item	C	Si	Mn	Cr	Ni	Cu	Fe	Mo	Cb	S	Al	Ti	Pb	V	P
Monel Studs (Cut Threads)	Required	0.3 max	.5 max	2.0 max	-	63-67	Bal.	2.5 max	-	-	.024 max	.5 max	-	-	-	-
	1/2"Studs	.14	.10	.93	-	64.21	33.03	1.56	-	-	.010	-	-	-	-	-
	7/8"Studs	.15	.19	.90	-	64.80	33.14	.79	-	-	.005	-	-	-	-	-
	1-1/8"Studs	.15	.10	1.13	-	64.12	33.84	.63	-	-	.005	-	-	-	-	-
K-Monel (Cut Threads)	Required	.25 max	1.0 max	1.5 max	-	63-70	Bal.	2.0 max	-	-	.010 max	2.0-4.0	.25-1.00	-	-	-
	1/2"Studs	.16	.10	.55	-	64.80	30.46	.60	-	-	.005	2.79	.51	-	-	-
	7/8"Studs	.16	.10	.55	-	64.80	30.46	.60	-	-	.005	2.79	.51	-	-	-
	1-1/8"Studs	.23	.11	.53	-	65.75	29.66	.56	-	-	.005	2.70	.43	-	-	-
Monel Studs (Rolled Threads)	Required	0.3 max	.5 max	2.0 max	-	63-67	Bal.	2.5 max	-	-	.024 max	.5 max	-	-	-	-
	K20-2A[1]	.144	.18	.84	.65	66.30	30.54	1.84	-	-	.018	.04	.05	.010	-	-
	K20[2]	.082	.12	.85	.03	65.54	31.28	1.91	-	-	.015	.05	.06	.009	-	-
	Q32-2A	.17	.09	.88	-	66.20	31.58	1.05	-	-	.007	.007	-	.007	-	-
	Q32-3A	.16	.13	.85	-	65.62	32.31	.90	-	-	.006	.015	-	-	-	-
	Q32-5HF	.17	.09	.88	-	66.20	31.58	1.05	-	-	.007	-	-	-	-	-
	Q32-5ONF	.19	.19	.90	-	64.58	32.84	.127	-	-	.010	.017	-	-	-	-
	S38[3]	.121	.16	.99	.13	64.61	32.31	1.59	-	-	.010	.04	.04	.006	-	-
K-Monel Studs (Rolled Threads)	Required	.25 max	1.0 max	1.5 max	-	63-70	Bal.	2.0 max	-	-	.010 max	2.0-4.0	.25-1.00	-	-	-
	K20-2A, 5HF	.19	.11	.57	-	65.62	29.60	.64	-	-	.007	2.77	.47	-	-	-
	K20-3A, 5ONF	.21	.22	.57	-	64.54	30.26	1.01	-	-	.005	2.76	.40	-	-	-
	Q32[3]	.13	.12	.68	-	65.00	29.99	.66	-	-	.005	2.89	.50	-	-	-
	S38[3]	.18	.14	.58	-	64.84	30.15	.62	-	-	.005	2.96	.50	-	-	-
Monel Casting	Required	.35 max	2.00 max	1.5 max	-	62-68	26-33	2.5 max	-	-	-	-	-	-	-	-
	Actual	.24	1.97	.96	-	63.2	31.01	1.22	-	1.40	-	-	-	-	-	-
HY80 Steel Casting	Required	.2 max	.50 max	.55-.75	1.35-1.65	2.50-3.25	.2 max	-	.30-.60	-	.015 max	-	.02 max	-	.03 max	.020 max
	Actual	.18	.28	.62	1.60	3.10	.15	-	.49	-	.006	-	.004	-	.01	.005

[1] Refers to sizes listed in Military Standard MS15991.

[2] For -.../- K20 studs having setting and thread classes 3A, 5HF and 5ONF.

[3] All studs of this size.

Table II Mechanical Properties

Material	Item	Tensile Strength (psi)	Yield Strength (psi)	Elongation in 2"(%)
Monel Studs (Cut Threads)	Required	80,000 min.	40,000 min.	20.0 min.
	All 1/2" Studs	106,500	102,000	23.0
	All 7/8" Studs	95,500	83,000	30.0
	All 1-1/8" Studs	90,500	77,000	31.0
K-Monel Studs (Cut Threads)	Required	130,000 min.	90,000 min.	20.0 min.
	All 1/2" Studs	178,700	148,200	20.3
	All 7/8" Studs	163,000	119,100	23.4
	All 1-1/8" Studs	151,500	107,200	24.2
Monel Studs (Rolled Threads)	Required	80,000 min.	40,000 min.	20.0 min.
	K20-2A 1/	92,300	80,100	23.3
	K20-3A	98,500	88,700	21.0
	K20-5HF	98,500	88,750	21.0
	K20-5ONF	86,000	65,000	23.8
	Q32-2A	96,200	73,700	29.2
	Q32-3A	100,200	77,300	27.3
	Q32-5HF	92,700	58,700	26.5
	Q32-5ONF	96,900	71,300	32.1
	S38 2/	81,200	56,300	33.7
K-Monel Studs (Rolled Threads)	Required	130,000 min.	90,000 min.	20.0 min.
	K20-2A	146,300	99,100	26.4
	K20-3A	143,600	99,100	26.6
	K20-5HF	146,300	99,100	26.4
	K20-5ONF	156,200	98,900	23.7
	Q32 2/	153,000	96,300	23.1
	S38 2/	152,700	91,600	28.4
Monel Casting	Required	65,000 min.	32,500 min.	25 min.
	Actual	78,400	39,900	45.0
HY80 Steel Casting	Required	For information only	80,000-95,000	20.0 min.
	Actual	113,000	92,000	22.5

1/ Refers to sizes listed in Military Standard MS15991.
2/ All studs of this size.

III THREAD GAGING AND DIMENSIONS

A. Thread Gaging:-

The Thread major diameter, minor diameter, pitch diameter, included angle and thread lead of each stud and bolt used in this program were measured at three points along the thread. An average of the three results for each dimension was used. The major diameter was measured on a Pratt & Whitney Super Micrometer. Tri-roll gages were used to measure the pitch diameter to an accuracy of 0.0001 inch. The included angle, minor diameter and lead were measured on a J & L Comparator to an accuracy of 0.0001 inch.

The pitch diameter and minor diameter of the internal holes were measured with a Bryant P-21 Thread Gage.

Deformation of studs caused by various amounts of interference was determined using a Scherr-Tumico optical comparator.

B. Thread Dimensions:-

Classes 2A and 3A UNC external threads and class 3B UNC tapped holes were in accordance with Handbook H28, Screw-Thread Standards for Federal Services.

Handbook H28 (1957) Part III (pages 48-52), provides dimensions for external and internal interference fit (class 5) threads. These dimensions and pitch diameter limits were based on the externally threaded members being steel ASTM A-325 (SAE grade 5) or better. In the absence of any other dimensional data, these dimensions in Handbook H28 were used when class 5 threads were required for the monel and K-monel studs used in this program. NC5 HF threads were used for monel and K-monel studs engaged in tapped

holes in HTS, HY80 plate and HY80 casting. NC5 ONF threads were used for K-monel studs engaged in tapped holes in monel castings. NC5 IF threads were used for tapped holes in HTS, HY80 plate and HY80 casting and NC5 INF threads were used for tapped holes in monel castings.

IV TEST PROCEDURE AND RESULTS

For the sake of clarity and continuity, both the test procedure and test results are included in this section.

Studs were engaged to the minimum length of engagement as determined in Task I. A summary of these minimum length of engagement data are included in Appendix I. With the stud engaged, a self-locking nut was installed until a length of two thread pitches extended beyond the locking device of the nut. The break-away and back-off torques for removing the nut were determined without any axial load applied to the nut (as specified in MIL-N-25027B, paragraph 4.5.3.2.2.1.1). Self-locking nuts from both Elastic Stop Nut Corporation (ESNA) and Greer Stop Nut Company were used in order to compare torque data for nuts supplied by different sources. The average torques for 1/2, 7/8 and 1-1/8 inch nuts are shown in Table III. The torques for the 1/2 and 7/8 inch nuts were obtained without applying any lubricant to the nut or to the nut end of the stud. When attempting to test the 1-1/8 inch nuts in a like manner, a considerable number balled up during back-off. Consequently, the break-away and back-off torques for the 1-1/8 inch nuts were obtained with the nut end of the stud lubricated with "3-in-One" SAE 20 oil. The nut end of the studs had UNC 2A threads.

Table III Break-away and Back-off Torques for Self-Locking Nuts

Size (inch)	Torque	ESNA	GREER
1/2	Break-away	118 in.-lb.	98 in.-lb.
	Back-out	76 in.-lb.	67 in.-lb.
7/8	Break-away	27 ft.-lb.	31 ft.-lb.
	Back-out	19 ft.-lb.	21 ft.-lb.
1-1/8	Break-away	33 ft.-lb.	-
	Back-out	18 ft.-lb.	-

The break-away and back-out torques for removing the studs were, subsequently, determined. These torques were obtained without any preloading of the studs. The test set-up for determining these torques is shown in Figure 1, which shows an HTS plate with 7/8 inch tapped holes, a monel stud, stud remover and torque wrench.

Monel and K-monel studs with classes 2A cut and rolled and 3A cut and rolled threads engaged in tapped holes with class 3B threads caused no observable permanent distortion of the external or internal threads. The break-away and back-out torques for these 2A/3B and 3A/3B fits were lower than the break-away torque for removing the self-locking nuts. The break-away and back-out torques for 1/2, 7/8 and 1-1/8 inch studs with class 5 threads engaged in tapped holes with class 3B and class 5 threads are tabulated in Table IV. The torques for the 1/2 and 7/8 inch studs were obtained with the internal holes lubricated with "3-in-One" SAE 20 oil. This lubrication, however, proved inadequate for the 1-1/8 inch studs. Break-away torques for the 1-1/8 inch studs were, in some cases, as high as 2000 ft.-lbs. because of seizing and balling up of the threads. This problem was remedied by lubricating the studs with Fel-Pro C-200 (Felt Products Manufacturing Company, Skokie, Illinois). 2/

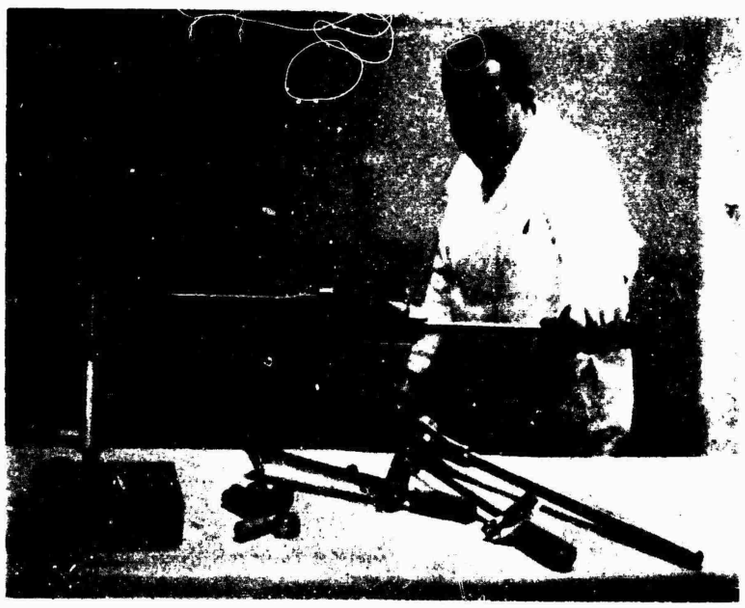

Figure 1 - Determination of Break-Away Torque

Table IV Break-away and Back-out Torques of Studs

Size: 1/2 inch Plate Material: HY80

Stud Material	Cut or Rolled[1]	Class 3B[2]	Interference	Class 5B[2]	Interference
K-monel	Cut	60-40[3] ft-lb	0.0060 inch	38-20 ft-lb	0.0051
	Cut	70-40 in-lb	.0011	30-25 ft-lb	.0036
	Rolled	120-90 ft-lb	.0047	38-25 ft-lb	.0054
	Rolled	45-32 ft-lb	.0016	30-23 ft-lb	.0022
Monel	Cut	60-45 ft-lb	.0070	30-20 ft-lb	.0071
	Cut	170-110 in-lb	.0017	29-19 ft-lb	.0038
	Rolled	60-45 ft-lb	.0054	45-30 ft-lb	.0053
	Rolled	45-30 ft-lb	.0008	20-12 ft-lb	.0024

Size: 1/2 inch Plate Material: HTS

Stud Material	Cut or Rolled	Class 3B	Interference	Class 5	Interference
K-monel	Cut	170-120 in-lb	0.0038	30-20 ft-lb	0.0049
	Cut	200-70 in-lb	.0028	30-20 ft-lb	.0043
	Rolled	30-20 ft-lb	.0019	55-40 ft-lb	.0049
	Rolled	25-15 ft-lb	.0001	35-20 ft-lb	.0044
Monel	Cut	60-35 in-lb	.0026	20-12 ft-lb	.0072
	Cut	25-15 in-lb	.0014	18-13 ft-lb	.0052
	Rolled	240-160 in-lb	.0022	35-22 ft-lb	.0052
	Rolled	60-50 in-lb	.0027	30-18 ft-lb	.0039

Size: 1/2 inch Plate Material: Cast HY80

Stud Material	Cut or Rolled	Class 3B	Interference	Class 5	Interference
K-monel	Cut	80-60 ft-lb	0.0045	25-15 ft-lb	0.0058
	Cut	33-25 ft-lb	.0037	60-50 ft-lb	.0003
	Rolled	82-60 ft-lb	.0042	38-35 ft-lb	.0048
	Rolled	20-18 ft-lb	.0028	30-26 ft-lb	.0026

Size: 1/2 inch Plate Material: Cast Monel

Stud Material	Cut or Rolled	Class 3B	Interference	Class 5	Interference
K-monel	Cut	250-100 in-lb	0.0072	60-50 ft-lb	0.0038
	Cut	50-35 ft-lb	.0015	45-35 ft-lb	.0023
	Rolled	70-45 ft-lb	.0064	110-80 ft-lb	.0052
	Rolled	45-30 ft-lb	.0031	55-35 ft-lb	.0034

Size: 7/8 inch Plate Material: HY80

Stud Material	Cut or Rolled	Class 3B (ft-lb)	Interference	Class 5 (ft-lb)	Interference
K-monel	Cut	380-320	0.0053	180-110	0.0085
	Cut	250-150	.0028	200-130	.0035
	Rolled	400-280	.0035	220-140	.0054
	Rolled	215-170	.0022	190-140	.0027
Monel	Cut	200-200	.0067	110-85	.0085
	Cut	50-35	.0029	65-25	.0008
	Rolled	170-140	.0079	210-190	.0062
	Rolled	150-100	.0018	80-65	.0016

Size: 7/8 inch Plate Material: HTS

Stud Material	Cut or Rolled	Class 3B (ft-lb)	Interference	Class 5 (ft-lb)	Interference
K-monel	Cut	260-180	0.0069	150-100	0.0069
	Cut	250-180	.0041		
	Rolled	260-190	.0058	300-240	.0052
	Rolled	230-180	.0017	210-160	.0025
Monel	Cut	110-60	.0045	160-130	.0074
	Cut	115-60	.0022	110-70	.0049
	Rolled	110-90	.0056	80-40	.0036
	Rolled	65-50	.0002	65-50	.0032

Size: 7/8 inch Plate Material: Cast HY80

Stud Material	Cut or Rolled	Class 3B (ft-lb)	Interference	Class 5 (ft-lb)	Interference
K-monel	Cut	300-240	0.0073	150-140	0.0068
	Cut			130-100	.0052
	Rolled	180-140	.0061	200-170	.0053
	Rolled	285-210	.0028	150-100	.0027

Size: 1-1/8 inch Plate Material: HY80

Stud Material	Cut or Rolled	Class 3B (ft-lb)	Interference	Class 5 (ft-lb)	Interference
K-monel	Cut	546-514	0.0083		
	Cut	267-236	.0095		
	Rolled	331-287	.0105		
	Rolled	353-331	.0110		
Monel	Cut	314-230	.0055		
	Cut	257-236	.0116	717-653	0.0044
	Rolled	316-224	.0087	118-108	.0046
	Rolled	599-428	.0056		

Size: 1-1/8 inch Plate Material: HTS

Stud Material	Cut or Rolled	Class 3B (ft-lb)	Interference	Class 5 (ft-lb)	Interference
K-monel	Cut	139-128	0.0031	300-278	0.0088
	Cut	353-331	.0062		
	Rolled	556-471	.0085	492-481	.0088
	Rolled	514-550	.0059	331-289	.0086
Monel	Cut	156-139	.0025	385-342	.0057
	Cut	194-160	.0063		
	Rolled	192-160	.0014	246-245	.0062
	Rolled				

Size: 1-1/8 inch Plate Material: HY80 Cast

Stud Material	Cut or Rolled	Class 3B (ft-lb)	Interference	Class 5 (ft-lb)	Interference
K-monel	Cut	171-139	0.0025	332-311	0.0082
	Cut	267-236	.0039	97-86	.0055
	Rolled	471-444	.0037	406-386	.0051
	Rolled	686-642	.0057	347-342	.0098

Size: 1-1/8 inch Plate Material: Monel

Stud Material	Cut or Rolled	Class 3B (ft-lb)	Interference	Class 5 (ft-lb)	Interference
K-monel	Cut			235-224	0.0033
	Cut	492-406	.0034	397-311	.0085
	Rolled	578-578	.0099	835-803	.0050
	Rolled			556-535	.0051

1/ Refers to stud thread.
2/ Internal Thread Class.
3/ Break-away-Back-off torques.

Several studs were reengaged to determine to what extent the break-away and back-out torques were reduced as a result of the first engagement. These data are tabulated in Table V.

Table V Break-away and Back-out Torques after Reapplication

Size (inch)	Stud Material	Stud-Cut or Rolled	Internal Thread Material	Internal Thread Class	Torques after First Application (ft-lb)	Torques after Reapplication
1/2	K-monel	Cut	HTS	5	30-20	60-30 in-lb
			HY80	5	38-20	200-50 in-lb
			Cast HY80	5	25-15	20-10 ft-lb
			Monel	5	60-50	200-130 in-lb
		Rolled	HTS	5	55-40	100-50 in-lb
			HY80	5	38-25	130-40 in-lb
			Cast HY80	5	38-35	26-20 ft-lb
	Monel	Cut	HTS	3	60-35	40-15 ft-lb
			HY80	5	30-20	180-50 in-lb
		Rolled	HTS	5	35-22	180-90 in-lb
			HY80	5	45-30	22-15 in-lb
7/8	K-monel	Cut	HTS	5	150-100	100-60 ft-lb
			HY80	5	180-110	40-25 ft-lb
			Cast HY80	5	150-140	80-40 in-lb
		Rolled	HTS	5	300-240	90-60 ft-lb
			HY80	5	220-140	30-25 ft-lb
	Monel	Cut	HY80	5	110-85	40-35 ft-lb
		Rolled	HTS	5	80-40	70-40 ft-lb

These studs were reengaged and axially loaded to their breaking point. The object of this load test was to determine whether the thread distortion occurring during engagement weakened them to a point where they would strip when the stud was loaded axially. In all the load tests performed, the stud broke without any stripping of the external or internal threads. All load tests were performed with the studs engaged to the minimum length of engagement determined from testing performed in Task I (see Appendix I).

Figures 2 through 5 show the deformation which occurred when monel and K-monel studs with cut and rolled, class 5 threads were engaged in class 5 tapped holes in HY80 plate. During driving, plastic flow occurs which results in an increase of the stud major diameter. Typical increases in major diameter resulting from interference fit are shown in Table VI.

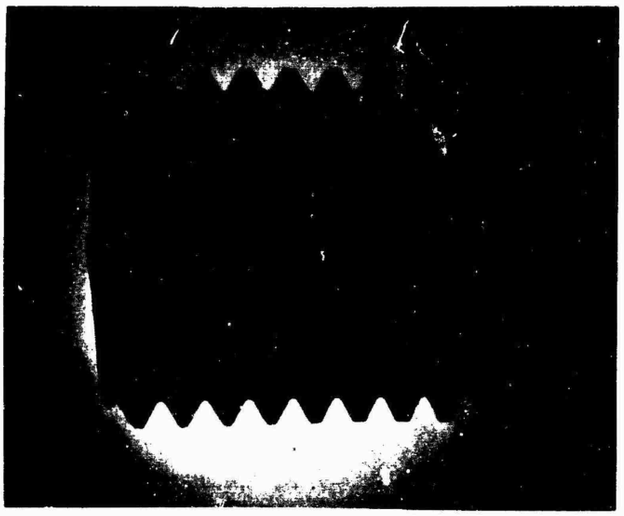

FIGURE 2: Deformation of a 7/8 inch K-Monel Stud with Cut, Class 5 Threads after Engagement in a Class 5 Tapped Hole in HY80 Plate.

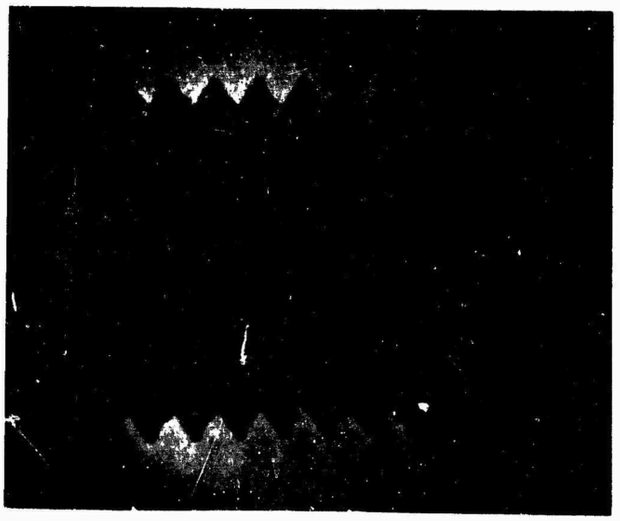

FIGURE 3: Deformation of a 7/8 inch Monel Stud with Cut, Class 5 Threads after Engagement in a Class 5 Tapped Hole in HY80 Plate.

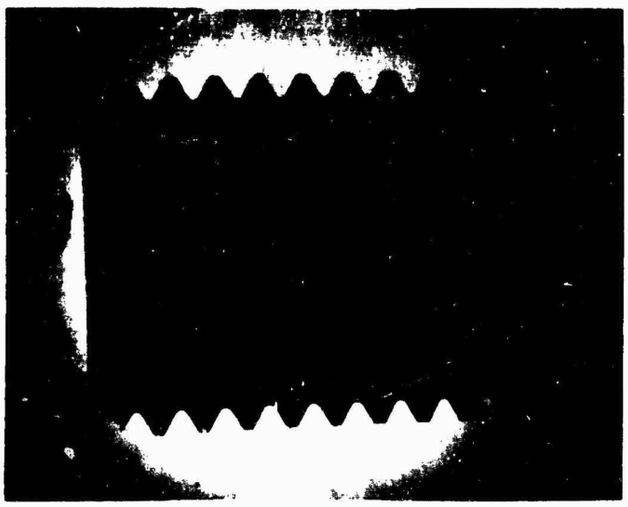

FIGURE 4: Deformation of a 7/8 inch K-Monel Stud with Rolled, Class 5 Threads after Engagement in a Class 5 Tapped Hole in HY80 Plate.

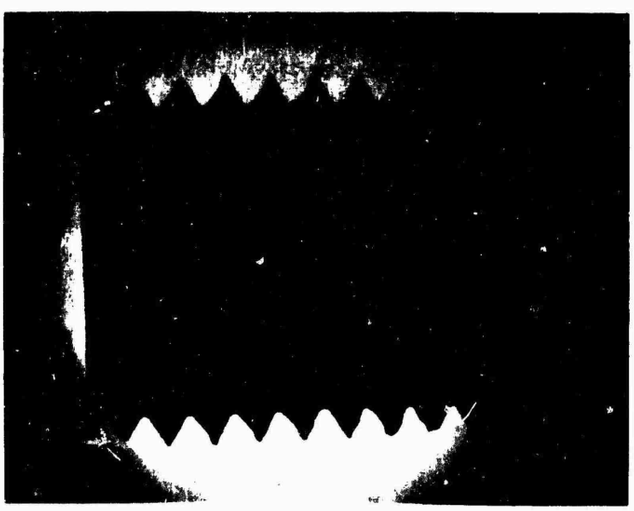

FIGURE 5: Deformation of a 7/8 inch Monel Stud with Rolled, Class 5 Threads after Engagement in a Class 5 Tapped Hole in HY80 Plate.

Table VI Increase in Stud Major Diameter as a Result of Interference Fit

Size (inch)	Stud Material	Stud-Cut or Rolled	HTS		HY80		Cast HY80		Monel	
			Major Diameter Change (inch)	Pitch Diameter Interference (inch)	MDC (inch)	PDI (inch)	MDC (inch)	PDI (inch)	MDC (inch)	PDI (inch)
1/2	K-monel	Cut	0.0031	0.0049	0.0029	0.0060	0.0040	0.0058	0.0071	0.0023
		Cut	.0020	.0028	.0012	.0011	.0010	.0037	.0052	.0015
		Rolled	.0017	.0044	.0097	.0022	.0017	.0048	.0054	.0064
		Rolled	.0056	.0019	.0012	.0016	.0059	.0026	.0084	.0052
	Monel	Cut	.0036	.0052	.0083	.0038				
		Cut	.0016	.0014	.0021	.0017				
		Rolled	.0001	.0039	.0043	.0008				
		Rolled	.0012	.0027						
7/8	K-monel	Cut	.0082	.0069	.0076	.0085	.0119	.0068		
		Cut	.0035	.0041	.0092	.0028	.0060	.0052		
		Rolled	.0081	.0052	.0060	.0054	.0044	.0061	.0130	.0023
		Rolled	.0007	.0009	.0031	.0027	.0119	.0027		
	Monel	Cut	.0210	.0074	.0224	.0085				
		Cut	.0144	.0045						
		Rolled	.0035	.0056	.0127	.0018				
		Rolled	.0029	.0036	.0105	.0016				

V GENERAL COMMENTS

Based on the test data, it is recommended that class 5 studs not be engaged in class 3B tapped holes. The smaller minor diameter of the 3B holes as compared to that of class 5 resulted, in many cases, in excessive driving torques and, in some cases, in seizing and galling of the threads.

In testing K-monel studs in tapped holes in cast monel, NC5 ONF threads were used for the studs and NC5 INF threads were used for the holes. Although not too much difficulty was experienced with the 1/2 inch studs, engaging 7/8 and 1-1/8 inch NC5 ONF studs in NC5 INF holes caused seizing and galling, in

the majority of tests conducted. In many cases, balling of the seized metal was so great that it resulted in torsional failure of the stud when attempting to back it out. The use of NC5 HF studs in the NC5 INF tapped holes in the cast monel greatly reduced the frequency of seizing and galling. The use of a lubricant such as the Fel-Pro C-200 also alleviated this problem of galling in the NC5 ONF/NC5 INF fit.

APPENDIX I

Table I Minimum Length of Engagement

Stud Material	Size (inches)	Minimum length of engagement (inches)			
		Internal thread material			
		Monel Casting	High Tensile Steel Plate	HY80 Steel Plate	HY80 Steel Casting
Monel	1/2	-	0.31	0.31	-
K-Monel	1/2	0.38	0.45	0.34	0.42
Monel	7/8	-	0.56	0.50	-
K-Monel	7/8	0.94	0.72	0.56	0.56
Monel	1-1/8	-	0.71	0.64	-
K-Monel	1-1/8	1.07	1.00	0.79	0.86